S
354.36
N7mws
1989

ANA WATER STORAGE

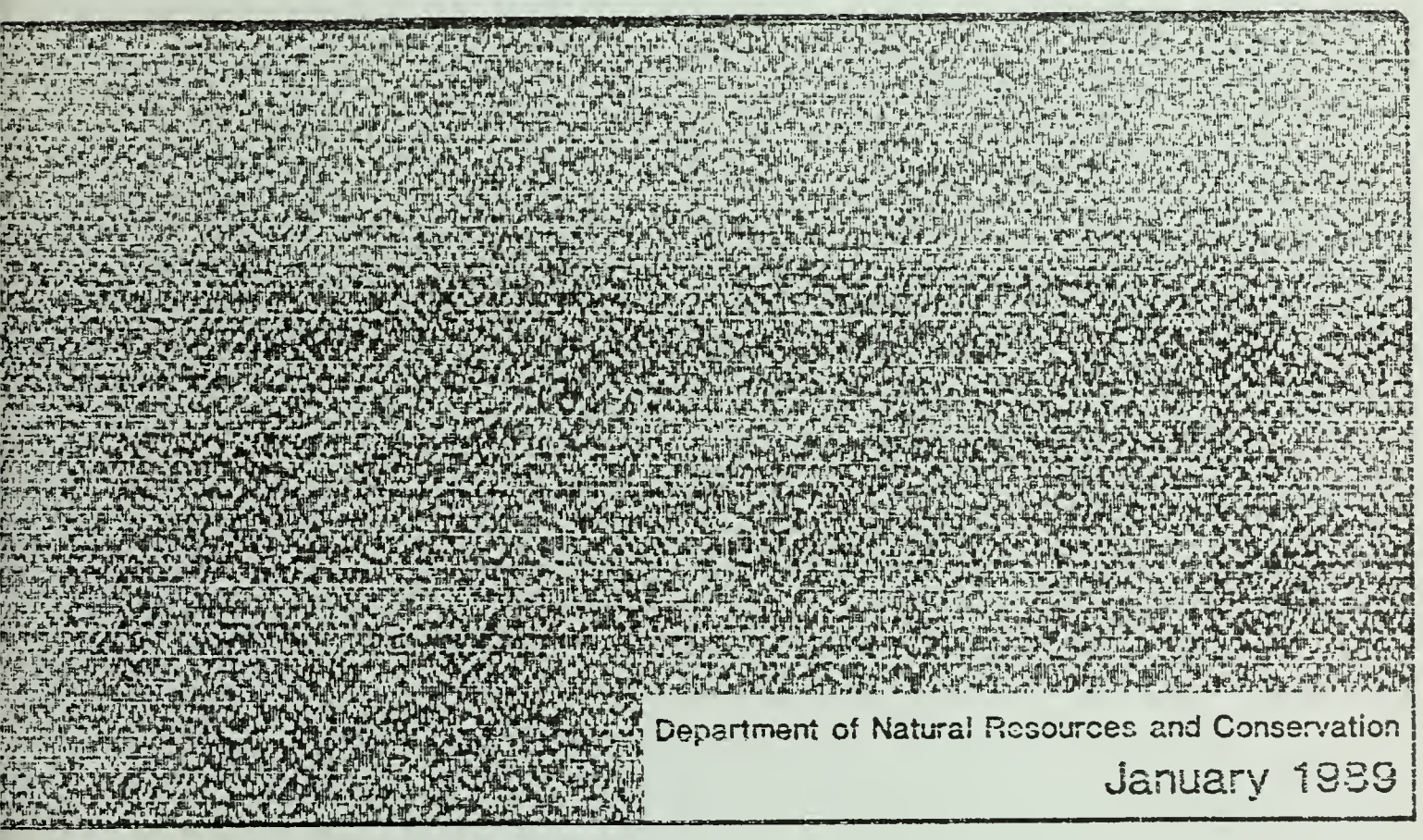
STATUS REPORT

STATE DOCUMENTS COLLECTION

JUN 20 2003

MONTANA STATE LIBRARY
1515 E. 6th AVE
HELENA, MONTANA 59620

DRAFT



Department of Natural Resources and Conservation

January 1989

MONTANA STATE LIBRARY
3 0864 1002 1207 8

FOREWORD

This report was prepared by the Department of Natural Resources and Conservation (DNRC) at the request of the Governor. A public advisory task force was created to assist DNRC with the preparation of this report and to make recommendations for further evaluation of water storage.

The Water Storage Task Force includes individuals from varied backgrounds and interests, each member offering a unique blend of expertise and perspective. Task force membership is listed below and their recommendations for the further evaluation of water storage are presented in this report. DNRC greatly appreciates the valuable advice, insight, and assistance each member provided in the preparation of this report. The views expressed in this report are DNRC's and do not necessarily reflect those of the task force members.

Dick Nesbit City of Helena	Stan Bradshaw Trout Unlimited
Jim Wedeward U.S. Bureau of Reclamation	Lorents Grosfield Big Timber
Roger Foster Morrison-Maierle Inc.	Jim Flynn Fish, Wildlife and Parks
Larry Gruel Montana Power Company	Verne House Montana State University
Dueane Calvin Montana Water Resources Association	Larry Fasbender Dept. of Natural Resources and Conservation

The Department of Natural Resources and Conservation would also like to acknowledge Larry Fasbender and Gary Fritz who provided guidance; Dave Aune who coordinated the report; Will Harmon who edited the report and provided writing assistance; Tom Ring, Lawrence Siroky, and John Tubbs who helped prepare sections of the report; Rose Bond and Mary Hofmann who typed the report; Gordon Taylor and Don Howard who did the layout; and the many DNRC staff members who provided valuable input.

DNRC would also like to acknowledge the input provided by the Soil Conservation Service, the Bureau of Reclamation, and the Department of Fish, Wildlife and Parks.

PURPOSE

Some river basins in Montana have experienced chronic water shortages affecting aquatic habitats, irrigators, municipalities, recreationists, and hydro power generators. These water shortages have reduced crop revenues, degraded valuable fisheries, increased domestic water supply costs, reduced recreational opportunities, and decreased hydropower generation. Preceded by a series of dry years, the severe drought of 1988 has increased public interest in the development of additional water storage in Montana. Many see new storage as the best answer to irrigation, municipal, industrial, and instream water shortages. Others view water storage as too expensive and environmentally damaging. To resolve this issue in the best interests of all concerned, the director of the Department of Natural Resources and Conservation (DNRC), at the request of the governor, created a public advisory task force. The task force assisted DNRC with the preparation of this water storage status report and made recommendations for further evaluation of the issues surrounding water storage.

This report does not address the specific needs of the many river basins in Montana or the viability of water storage as a solution to specific water shortage problems. Such an effort would require a more detailed water planning study. Rather, the intent of this report is to provide general information that will serve as a foundation for the governor, legislature, and the State Water Plan Advisory Council to continue discussions about the need for and viability of additional water storage and its possible role in Montana water management. Such discussions will require detailed knowledge of the financial, economic, safety, social, and environmental aspects of additional water storage development.

Managing the state's water resources should take into account the unique blend of natural surroundings, geologic features, economic needs, and social priorities of each river basin. Such an approach would generate basin-wide, basin-specific plans relying on a variety of water management tools, including storage development. Other measures such as conservation, improved water management, and existing storage enhancement will also be needed to effectively respond to continued water shortages in Montana. Because storage projects are expensive and permanent, the possible use of storage in managing Montana's water resources calls for thoughtful consideration and prudent planning and implementation.

EXECUTIVE SUMMARY

Existing water storage projects provide many benefits to Montanans, such as municipal, industrial, and stockwater storage; inexpensive hydroelectric power; flatwater recreation; and regulated streamflows for irrigation, flood control, and fishery purposes. Further development of water storage in Montana might help to alleviate water shortage conflicts such as the instream flow/irrigation issue and provide economic development opportunities. However, additional storage will probably not add susbtantially to the recreation and flood control benefits provided by existing water storage. Water storage projects also produce undesirable side effects. Dams inundate prime agricultural land and wildlife habitat, damage fisheries, and alter unique landscapes and historical sites. Clearly, the effects of water storage are many, varied, and unique (site-specific) to each reservoir. This complexity, coupled with differing social needs and priorities, suggests that the net effect of water storage is not easily understood or characterized.

Water resources development has primarily been directed by the needs and priorities of the general public. In Montana's early days, water development consisted of short ditches and small reservoirs to meet the needs of miners and small farms. With the coming of electricity in the 1880's, the demand for Montana's copper accelerated and hydroelectric power was developed near the state's copper smelters to meet this demand. Simultaneously, the coming of the railroads expanded agricultural markets and associated irrigation.

As agriculture grew, there was a need for larger systems that were often beyond local development capabilities. About that time the federal government was interested in settling the west, and the Bureau of Reclamation was created to develop irrigation in the arid west. Many of Montana's early water storage projects were built by the Bureau under this mandate.

The depression era represents a unique period for water resources development in Montana. The federal government created work programs to relieve unemployment. Montana was the only state able to put these programs to work developing water resource projects. To do this, a special legislative session created the State Water Conservation Board in 1935 for the purpose of using federal work program funds to relieve unemployment and develop water. After the depression, the federal work programs were eliminated and board activities slowly diminished to the point of maintenance and rehabilitation of state-owned projects. The board's successor, the Water Resources Division of the DNRC, continues to perform this maintenance and rehabilitation function.

As the country expanded to the west, there was public need for improved navigation for interstate commerce and additional electric power for economic development. This, coupled with the need for flood control and the ancillary benefit of flatwater recreation, fueled the drive for water storage development. Accordingly, water storage development was pursued by the federal government and typically was supported by the general public. This public support slowly eroded in the late 1950s and 1960s due to the great expense of water storage development and the less obvious need for additional storage in consideration of the existing benefits of storage.

In the 1970s, federal water policy shifted markedly from water development toward preservation and enhancement of water quality. Development was no longer seen as a necessary or inevitable response to growing demand. In addition, a string of federal laws was passed to protect the nation's land and water resources, and these greatly complicated the prospects of new development. Consequently, Montana has not seen large-scale development since the construction of Libby Dam in 1972.

The Bureau of Reclamation and the Soil Conservation Service have been the most active federal water development agencies in Montana and have generally offered the best opportunity for federal development in the past. Because of budget limitations, the SCS currently does not place a priority on water storage development, and the Bureau of Reclamation requires 50-percent cost share for planning and engineering and a negotiated cost share for construction, a significant departure from the 100-percent Bureau funding of the past. In addition, a recent executive order established a policy of no new federal construction starts.

Considering the large national debt, the absence of past incentives, and an expanded national water resources agenda that includes pollution abatement, groundwater management, and other less traditional concerns, it is not likely that the federal role in water storage development will expand, and it may even diminish.

Currently, the biggest limitation to additional water storage development is the high cost of development and the lack of public (state or federal) funding due to changes in the social needs and priorities that drive public policy. In recent years the nation has placed a priority on other water issues such as water pollution control and groundwater management, which tend to divert resources away from water storage development. The result is a reduced availability of federal funds for storage development. Accordingly, water storage development in Montana might require resourceful financing methods and cooperation among local, state, and federal parties, and may also require considerable state expenditures.

Environmental considerations in certain cases may also limit storage development. Past efforts to mitigate environmental impacts have allowed development to occur, though some have argued that the effectiveness of mitigation needs to be reexamined. The uncertainty of legal water availability also may tend to restrict water storage or delay it until water rights issues are resolved.

The first step in the process of determining the role water storage might play in Montana water management should be to reach a consensus on the social objectives of water storage (e.g., irrigation, enhanced streamflow, etc.). Such consensus-building would be a considerable challenge and could require innovative approaches. Expenditure of state funds would be justifiable upon the establishment of common objectives for water storage that mutually benefit all Montanans. Such a scenario would require establishment of water storage criteria that control the decision-making process. When evaluating water storage, consideration should be given to all of the effects of water storage

and to the many technical details associated with project feasibility. The site-specific and incremental nature of the effects of water storage suggest that the role of additional storage be evaluated on a case-by-case basis, subject to the relative merits of the project being considered.

Also, the state should not overlook the need to rehabilitate existing structures and the opportunity to enhance current storage capacities or reallocate existing storage use on large projects. A commitment to long-term operation, maintenance, and rehabilitation should be a part of any state action.

Water resources management must respond to the range of common public needs. Considering the diversity of these needs, it is difficult to develop a project that is not constrained by one or more of the numerous social, environmental, and economic complexities associated with water storage development. Because of these complexities, and the expensive and permanent nature of water storage, the pursuit of development would require thoughtful and prudent planning and implementation that relate water storage to the broader issues of land and water resource management.

WATER STORAGE TASK FORCE RECOMMENDATIONS

Based on the contents of this document and each task force member's experience and knowledge of water storage, the following recommendations were developed. It is important to recognize that the scope of the task force's efforts do not allow for specific and detailed recommendations. As a result, the following recommendations tend to be somewhat general and are offered with the intent of directing future planning efforts in regard to water storage.

1. The issue of water storage should be considered as a separate subsection by the State Water Plan in the next planning cycle.

2. Water storage should be considered one of the water management options available to solve water shortage problems, but because storage is expensive, site-specific, and permanent, its use should be carefully evaluated and established on a case-by-case basis using site-specific analysis.

3. Because water shortage problems can be addressed in many ways, water storage should be evaluated as it relates to alternative solutions (e.g., conservation, improved reservoir operation, and improved water management in general), and to the broader scope of water and land resource management.

4. To ensure the uniform evaluation of water storage, Montana should develop criteria for the analysis and comparison of water storage projects. These methods would include ways of measuring project benefits and costs.

5. Operation and maintenance resource and budget requirements should be included in the decision-making process when considering storage.

6. Procedures should be established to ensure that all project benefits are realized.

7. The need to repair and rehabilitate existing water storage projects should be addressed.

8. The expansion of existing water storage projects should be considered.

9. Montana should improve the accuracy, completeness, and accessibility of water storage data.

THE HISTORY OF WATER STORAGE DEVELOPMENT IN MONTANA

THE EARLY DAYS

The first water developers in Montana were gold miners in the 1860s who used water for their placer operations. Water storage projects were often built to regulate placer stream flow. Park Lake south of Helena is an example of early, mine-related storage. Homesteaders soon followed the miners, creating an agricultural industry around mining communities. To thrive in Montana's semi-arid climate, the homesteaders relied on small irrigation systems.

Growth of irrigation

In the 1880s the railroads linked Montana to large markets for crops and cattle, and agriculture began to dominate water development. The development of short ditches from rivers was common, and the census of 1890 shows that 66 percent of the farms and stock ranches were irrigated.

Early irrigation in the valleys largely exhausted opportunities for cheap development. Cooperative ventures and private ditch companies were formed in an effort to pool capital and labor. More ambitious projects were pursued, such as the Big Ditch, designed in 1883 to irrigate the Billings area. The Big Ditch Company is still in operation today. In fact, about half of the privately developed irrigation systems operated by canal companies today were built before 1900.

But the capital required for larger projects exceeded local capability, and the state and federal governments were brought into the picture. A state convention was called in Helena in 1892, and a resolution was passed to demand that the federal government use the revenue from the sale of public lands for reclamation purposes through water development. In 1903, the state legislature formed the Carey Land Act Board to promote project development, and the Billings, Big Timber, and Valier projects were completed. The Valier project is still operated today by the Pondera Canal Company.

Growth of private hydropower

Non-federal hydropower storage development followed the industrial, commercial, and residential demand for electricity that arose after the introduction of electric lighting in 1880. The electricity boom created a demand for copper (used as wire), and the copper industry grew rapidly, in turn requiring more electric power development to run mining and smelting operations.

In the 1890s hydropower facilities were built near the place of use, such as the Black Eagle Dam near the Great Falls smelter and the Flint Creek Dam near the Anaconda smelter. Increasing demand and technological improvements in long-distance transmission led to the construction of Madison, Hauser, Rainbow, and Milltown dams by 1910. The consolidation of 40 small power companies over the years culminated in the formation of the Montana Power

Company in 1912. By 1915 the demand for upstream storage to make water supply more reliable led to larger projects, including Hebgen Lake, at that time the seventh largest reservoir in the world. The Teens also saw the completion of Lake Creek, Holter, Ryan, and Thompson Falls in response to increasing loads on the system.

THE INFLUENCE OF FEDERAL WATER POLICY

At a time when western states were pursuing water development to the limits of their financial and labor resources, the federal government took an interest in water storage projects to promote settlement and farming in the West's semi-arid lands. In 1902, the federal government created the Bureau of Reclamation with the mandate of developing irrigation projects. This mandate guided the ongoing expansion of Montana's agricultural economy, and the state gained a number of federally funded, irrigation projects. These early projects included Willow Creek Dam (1907-11), Lake Sherburne Dam (1914-1921), Nelson Dikes (1914-15), Gibson Dam (1926-29), and Pishkun Dikes (1930-31).

Targeting unemployment

During the Great Depression, the federal government sought to alleviate unemployment by establishing public works programs. Though these programs were not specifically aimed at resource management, Montana legislators saw them as an opportunity to continue water development in the state. Several states attempted to take advantage of these public works programs to develop water resources, but Montana was the only one to endure the many federal requirements and successfully build water resource projects through the Public Works Administration (PWA) and the Works Progress Administration (WPA). To do so, a special legislative session was called in 1933 to create the State Water Conservation Board.

The State Water Conservation Board worked with the PWA, WPA, Reconstruction Finance Corporation, and the Civilian Conservation Corps (CCC) from 1934 to 1938, trying to develop water resource projects and reduce unemployment. The selection of a project for development was based not only on technical and economic issues, but also on maximizing the effect on unemployment. Thus, projects were more often built in areas of high unemployment, and the most economically viable sites were not always the ones selected.

In all, 181 water projects were built in Montana by the board. One hundred and forty-one of these were reservoirs capable of storing, at that time, 438,017 acre-feet. The PWA received applications for 67 projects from the State Water Conservation Board and provided loans and grants for 18 projects. The Reconstruction Finance Corporation provided a loan for one project. Most of these projects are still in existence and include most of the larger state-owned projects. In addition, an agreement was reached with the WPA in 1935 to provide loans and grants to Montana for water conservation projects that relieved unemployment. One hundred and twenty-eight small projects were built using these funds. Some of these projects were not serviceable, and others have been turned over to the water users associations.

The Water Conservation Board also received cooperation from the CCC in building two other projects. The remaining 32 projects were financed principally by state appropriations in the years following the elimination of federal work programs.

Federal grants funded 33 percent of the total costs of all the projects developed by the State Water Conservation Board. Another 20 percent was funded through federal loans. These loans were substantially reduced in later years due to project financing difficulties. The remaining 47 percent was covered by state appropriations. Specific projects receiving federal assistance were given grants in excess of the 33 percent reported here. The 33 percent is an average and incorporates all of the projects developed by the board, some of which were entirely funded by state appropriations. Many of the federally funded projects received grants in excess of 75 percent of the total project costs.

The Bureau of Reclamation built two projects in Montana during the Depression years: Anita Dam (1933-37) and Fresno Dam (1937-39). Anita was built by the CCC, and Fresno was built under the National Industrial Recovery Act.

The severe drought of the 1930s heightened the need for soil and water protection. As a result, the Soil Conservation Service (SCS) was established in 1935 to provide technical and financial assistance in the management of land and water resources. Since its inception, the SCS has helped in the construction of over 3,000 stockwater and irrigation reservoirs in Montana. The Agricultural Stabilization and Conservation Service (ASCS) provided the financial assistance to the majority of these projects. Cost share varied between 35 and 75 percent of total project costs.

Flood control

The economic crisis of the 1930s was punctuated with other disasters, including major flooding. The severity of these floods prompted Congress to pass the Flood Control Act of 1936, which focused on integrated river basin planning and greater coordination among federal water management agencies. States were encouraged to join in the federal planning process for the first time. The act also required that a cost/benefit analysis be performed for each federal water project. This spurred the uniform application of economic analysis to all water resource development, which has continued today. Prior to this act, it was believed that the benefits created by a project (with the exception of irrigation) were too general and dispersed to be credited to specific beneficiaries. As the Depression waned, the federal government continued to look at water development from an economic perspective, steering management toward improved efficiency and sustained prosperity. To achieve these goals, water development in neighboring states was coordinated into extensive, basin-wide plans.

In 1944 another flood control act authorized the Pick-Sloan Plan, which concentrated on the Missouri River Basin and had important ramifications for Montana. The plan was implemented by the U.S. Army Corps of Engineers and Bureau of Reclamation and centered around Missouri main-stem storage for flood

control, hydropower and irrigation development, and downstream navigation. The plan was responsible for all of the post-war development in the Missouri River Basin of Montana. Pick-Sloan dams include Canyon Ferry (1949-1954), Tiber Dam (1952-56), Helena Valley Dam (1957-58), Clark Canyon (1961-64), and Yellowtail Dam (1961-66). Fort Peck (1935-39) was built under the River and Harbor Act of 1935 and was retroactively included under the umbrella of the Pick-Sloan Plan. In compensation for acres lost to inundation, the upstream states were to receive irrigation assistance and "Pick-Sloan" power at reduced rates. To date, Montana has received few of these benefits; only 45,582 irrigated acres have been developed out of the 969,130 acres authorized. Yet the Army Corps of Engineers has estimated that the Pick-Sloan plan has produced several billion dollars worth of benefits in flood damage prevention and power generation.

The federal government also had a basin plan for the Columbia River Basin, including the entire Clark Fork watershed in Montana. Under this plan, Hungry Horse Dam was built in 1948-53 by the Bureau of Reclamation, and Libby Dam was built by the Army Corps of Engineers in 1968-72.

Serving many purposes

These basin-wide plans tried to address most of the concerns associated with water development, and it was often necessary (and advantageous) to design projects that served more than one function. By the 1960s, the federal government was also paying more attention to state and local interests, scientific research, and water resources education.

The creation of the National Water Commission in 1968 signaled a major turn in the direction of federal water management. The commission forecast a shift in priorities away from water development toward the preservation and enhancement of water quality. Development was no longer seen as a necessary or inevitable response to growing demand. Storage projects continued to be built, but resource managers began to rely more upon water conservation practices to meet demands.

By the 1970s, concern over declining water quality and other environmental issues had nearly stopped the development of water projects. Economic viability was no longer the sole concern in deciding whether to build a project. A string of federal laws had been passed to protect the nation's water and land resources, and these greatly complicated the prospects of developing new sites. Federal funding was, and continues to be, in short supply, further limiting development opportunities. The passage of the Water Resources Development Act in 1986 required non-federal cost sharing and up-front, non-federal financing during construction. This is a significant departure from past policies of federally funding nearly 100 percent of project costs.

In addition, the federal government has issued a recent executive order asserting a policy of no new water development construction starts. It is uncertain how long this policy will prevail, but it is likely to remain in place until most federal projects already under construction are completed. Federal projects have also been restricted recently by concern over double

subsidies; that is, providing irrigation cost share for projects that irrigate surplus, government-subsidized crops. It should be noted that Montana produces a very small quantity of surplus, subsidized, irrigated crops.

THE FEDERAL ROLE TODAY

This brief history of water storage development in Montana has clearly illustrated the strong influence exerted by federal activities and policies on development in our state. With the exception of private hydropower development and small, scattered storage projects, essentially all of the state's water storage projects have been built or largely financed by the federal government. The federal role in water storage development is likely to diminish in the foreseeable future, as suggested by the constraints of a large national debt, the absence of past incentives, and an expanded national water resources agenda that includes pollution abatement, groundwater management, and other less traditional concerns.

Presently, five federal agencies are involved in water resource development in Montana. They are the Bureau of Reclamation, the Army Corps of Engineers, the Soil Conservation Service, the Agricultural Stabilization and Conservation Service, and the Bureau of Indian Affairs. A discussion of the present status of these agencies follows, and Appendix A contains an inventory of existing water storage projects in Montana, including federally owned sites.

Bureau of Reclamation

The Bureau of Reclamation was created to facilitate the reclamation of the semi-arid regions in 17 western states. Its original mission was primarily irrigation development, but with time the agency was incorporated into the basin-wide planning process that evolved after World War II. Cooperating with the Corps of Engineers, the bureau developed multipurpose storage projects that were part of an overall basin plan. The Missouri River Pick-Sloan plan is an example of such a basin-wide plan.

The bureau provides planning, engineering, contract administration, construction inspection services and, in many cases, operates and maintains the development. Large bureau projects are developed in stages (planning, engineering, and construction), with each stage receiving separate congressional authorization through specific acts.

In the past, these funding authorizations covered the majority of the planning, engineering, construction, and operation and maintenance costs. The current policy of the Bureau of Reclamation regarding planning investigations requires 50 percent non-federal funding. This can be provided as cash, in-kind services, or a combination of both. With regard to construction, non-federal cost sharing is determined usually on a case-by-case basis unless specifically legislated. A recent example is the Mni Wiconi Rural Water Supply project in South Dakota, which required 35 percent non-federal cost sharing as a provision of the legislation. An example of a negotiated cost share is the Buffalo Bill Dam modification; the state of Wyoming provided a

47-percent cost share. The project sponsor is also required to provide more operation and maintenance support.

The Small Reclamation Projects Act of 1956 is also administered by the Bureau of Reclamation. This act established a program under which organizations can obtain loans for water resource projects and grants for those portions of projects that are classified nonreimbursable. The loans are long-term, and the repayment period can extend up to 40 years. The portion of the loan assigned to irrigation service for lands held in private ownership not in excess of 320 irrigable acres is free of interest charges. Interest is charged on the loan for the remaining reimbursable portions of the project. Repayment interest rate for FY 1989 is 9-1/8 percent.

Grants may be made for nonreimbursable portions of the project when the purposes are for public benefits, including flood control, outdoor recreation, and fish and wildlife purposes.

Project proposals may be solely for irrigation or drainage of irrigated lands or may be for multipurpose projects eligible for authorization under federal reclamation laws. Multipurpose projects may include irrigation; drainage; domestic, industrial, or municipal water supply; hydropower; flood control; fish and wildlife enhancement; or outdoor recreation.

The limit of federal funds that may be provided by loan or grant or combination thereof is $28.6 million (effective through December 1988).

Corps of Engineers

The Corps of Engineers is a regularly constituted branch of the United States Army with extensive military engineering and construction responsibilities. The Corps is also actively engaged in developing and implementing plans for flood control, navigation, and water conservation as primary civil functions under federal law.

The Corps involvement in civil projects was initiated when Congress, in 1824, directed the Corps to work on waterways so that improved transportation could encourage settlement of the West. Since that time, the Corps has expanded its efforts into flood control, water supply, hydroelectric power, and recreation.

The Corps planned, designed, built, and operates two large reservoirs in Montana--Libby Dam and Fort Peck. The Corps has also been involved in numerous flood control projects around the state. Corps projects are funded by direct congressional appropriations in specific water development acts, similar in many instances to how Bureau of Reclamation projects are funded.

Soil Conservation Service

The Soil Conservation Service offers water resource technical and financial assistance through the Watershed Protection and Flood Prevention Act of 1954 (P.L. 566) and the Resource Conservation and Development Program. These programs differ from the Bureau of Reclamation and the Corps of

Engineers in how the financial and technical assistance is budgeted. Congress appropriates fixed amounts to these programs annually rather than through project-specific acts. Consequently, each state competes for this annual appropriation.

Reservoirs constructed under the Watershed program (P.L. 566) are limited to 25,000 acre-feet of total capacity. The initial purpose of P.L. 566 projects was soil conservation and rural flood control, but in 1961 the first dam was constructed with irrigation as an eligible purpose. The construction cost of flood prevention dams are eligible for a 100-percent cost share under this program. Purposes other than flood prevention, such as irrigation and recreation, are typically cost-shared at the 50-percent level.

The Resource Conservation and Development (RC&D) program is designed to accelerate resource development in multi-county areas. This program was approved by Congress in 1962 and applies only to designated, multi-county RC&D areas. In Montana, there are three resource areas covering 12 counties. As a part of resource development through this program, several irrigation reservoirs have been rehabilitated in Montana. The RC&D program could also allow SCS technical and financial assistance to be used on the construction of new storage projects. RC&D cost sharing ranges between 50 and 65 percent.

Until a few years ago, the construction of economically justifiable irrigation and water storage projects was actively promoted by SCS. Since 1980, however, federally aided, water resource development projects of any kind, and especially those related to irrigation development, have been carefully screened prior to starting planning. Accordingly, no P.L. 566 projects have been developed in Montana since 1980 that have irrigation water storage as an essential element. Several projects have been developed since 1980 under P.L. 566 and RC&D that promote the conservation of existing water supplies, such as gravity sprinkler irrigation systems.

Budget constraints are the primary reason for the change in attitude toward project planning. The desire to limit the size of the federal work force has forced agencies to prioritize what jobs will be worked on. With a limited staff of specialists, the SCS is attempting to reach a large number of agricultural producers to work on broader resource problems. For these reasons, water storage and irrigation-related projects have been given low priority from the SCS national office. At present, unless project action has significant beneficial impacts on downstream water users or improves habitat for fisheries or wildlife, it is highly unlikely that an irrigation-related project will be given a planning start. This low priority rating extends into construction of new projects. In an effort to balance the budget, the money that is appropriated by Congress for the design and construction of P.L. 566 projects has been reduced. This increases the competition for the money on a national level, and those projects that benefit a greater number of people (such as flood control in more populated areas) have a better chance of receiving these limited funds.

Agricultural Stabilization and Conservation Service

The Agricultural Stabilization and Conservation Service provides financial assistance to private individuals for conservation projects through the Agriculture Conservation Program. The Soil Conservation Service provides technical assistance to projects funded under this program. The program can provide up to a 75-percent cost share. Program funding is limited to relatively small water storage projects. Approximately 800 dams have been built in Montana with ASCS financial assistance.

Bureau of Indian Affairs

The Bureau of Indian Affairs water development program plans, constructs, maintains, and operates irrigation projects on Indian reservations throughout the West. Over the years, the construction and administration of some projects have been transferred back and forth between the Bureau of Indian Affairs and Bureau of Reclamation.

The Bureau of Indian Affairs began its first water development program in 1867 with a small canal on the Colorado River Reservation. However, the Bureau of Indian Affairs irrigation program developed slowly, as no professional engineers were hired and only several small projects were constructed by the turn of the century.

The Bureau of Indian Affairs has irrigation projects on six of the seven Indian reservations in Montana. The first Indian irrigation development in Montana began in 1885. A total of 23 storage sites exist on the reservations for a total combined storage of 253,276 acre-feet.

The Winters decision of 1908 had the potential to initiate additional water development on reservations. Yet until recently, the reserved water rights doctrine has not been used as a catalyst for new Indian water development projects.

During the past session, Congress approved three water rights settlements for Indian tribes in Arizona, California, and Colorado. In each case, the settlements included development and/or rehabilitation of water storage and delivery systems with payment for the projects based on complex cost sharing between the local interests and state, tribal, and federal governments. The potential for water development under circumstances similar to these also exists in Montana.

THE STATE ROLE TODAY

After the elimination of federal work programs in the 1930s, the state of Montana's direct involvement in water storage development slowly diminished to the point of providing maintenance and rehabilitation services through the State Water Conservation Board to state-owned projects. Existing state-owned water storage projects are inventoried and described in Appendix A.

As mentioned previously, the State Water Conservation Board is the predecessor to the Water Resources Division of DNRC. The Department continues

to provide maintenance and rehabilitation services to state-owned projects. Each project's water users association is largely responsible for the operation and maintenance of the individual projects.

The Army Corps of Engineers inspected 22 state-owned projects in the early 1980s. Twelve of those projects were declared unsafe, primarily due to inadequate spillway capacity to meet current dam safety criteria. DNRC is actively pursuing dam safety rehabilitation by completing feasibility studies and pursuing funds to rehabilitate the projects. The feasibility studies and minor repairs are typically funded by a fixed annual appropriation from the Water Development Special Revenue Account. Major construction funding is presently being pursued through the Bureau of Reclamation's Small Projects Reclamation Act. Because of the federal government's no-new-constructions state policy, these projects have been put on hold until federal policy changes or other funding sources are identified. Other major and necessary rehabilitation projects have not proceeded because the projects are not able to recover the rehabilitation costs. Current dam safety rehabilitation needs are very expensive and, in many cases, have been beyond the financial capabilities of the local water users associations and the state.

The Department of Fish, Wildlife and Parks owns recreation sites on several major federal water storage projects, plus 16 water storage sites. The DFWP projects are very small and typically provide recreation, wildlife, or fisheries benefits.

DFWP has recently had trouble financing annual operation and maintenance of its recreation sites. As a result, DFWP has either released or returned five recreation sites back to the federal government.

The Water Development Program and the Renewable Resource Development Program administered by the DNRC are the only state financial assistance programs that specifically include water storage development as an eligible purpose. These programs can provide state grants of up to $100,000 to private and public organizations; private loans less than $200,000 (at approximately eight percent interest); and coal severance tax loans of more than $200,000. The coal severance tax loan program has the ability to subsidize interest rates and is the only program capable of funding multi-million-dollar projects. The coal severance loan program as established in S.B. 409 may issue up to $250 million in Montana coal severance tax bonds "for financing specific water resources development projects and activities in the state authorized by the legislature." The Water Development Program has funded one small water storage project and two dam rehabilitation studies for private organizations and local governments. The Water Development Special Revenue Account also provides funds for the rehabilitation of state-owned projects.

THE EFFECTS OF EXISTING WATER STORAGE

Water storage projects provide many benefits to society. Reservoirs store water for municipal, industrial, and stockwater consumption; provide flatwater recreation; supply potential energy for hydropower generation; and regulate streamflows for irrigation, flood control, hydropower, and fishery purposes. But water storage projects also produce some undesirable side effects. Dams have inundated prime agricultural land and wildlife habitat, blocked fish migrations, altered unique landscapes and historical sites, and reduced stream fishery populations. Of course, each project produces benefits and side effects that are specific to the project site, the type of dam and reservoir, and the intended purpose of the project. In other words, the beneficial and adverse effects of water storage are site-specific.

The following chapter presents a general picture of how existing water storage has affected the quality of life in Montana. It is important to bear in mind that each of the following benefits and side effects does not occur at every storage site. Yet all of them must be considered during the planning stage to maximize the site's usefulness and avoid unwanted impacts.

BENEFICIAL EFFECTS

Recreation sites have been developed on many of Montana's medium- to large-sized reservoirs. These sites have allowed thousands of Montanans and out-of-state visitors to enjoy flatwater recreation such as swimming, boating, water skiing, sailboating, and fishing. In many locales, limited or no flatwater recreation opportunities existed prior to the development of reservoirs. The estimated recreational use of several Montana water storage sites are presented in Table 1. Many of these reservoirs are noted for their good fishing, due primarily to the fish stocking efforts of the Department of Fish, Wildlife and Parks. In FY 1988, DFWP planted 35,565,000 warm-water fish such as walleye, bass, and northern pike, and 8,115,000 trout and salmon into reservoirs and lakes around the state. Flatwater recreation and fishing opportunities furnished by reservoirs are highly valued by many Montana residents.

Table 1.

Approximate Visitation between Memorial Day Weekend and September 30 as Determined by Traffic Counter Data(*) or Feeder Route Trends.

Reservoir	1984	1985	1986
Painted Rocks	6,100	4,900	no count
Harrison Lake	13,500*	14,000*	14,500*
Martinsdale Reservoir	no count	23,500	28,300
Newton Creek Reservoir	46,200	no count	48,000
Nilan Reservoir	8,000	7,500	7,800
Pishkun Reservoir	4,400*	4,000*	5,200*
Cooney Reservoir	235,100	122,900*	131,200
Deadman's Basin (east)	27,300*	25,100	21,000
Nelson Reservoir	no count	29,600*	16,900*
Tongue River Reserv.	54,200	50,900	30,600*
Helena Valley Reserv.	21,700	23,500	no count

Source: DFWP 1988

Fisheries such as the Missouri River below Holter Dam and the Bighorn River below Yellowtail Dam have benefited from the regulated flows associated with reservoirs. The reduced sediment loads, stabilized temperature, and controlled flows have all combined to enhance aquatic habitat and fish populations.

Water storage has also improved instream flows in rivers experiencing chronic water shortages. This has protected and enhanced fish populations and improved boating opportunities. For example, DFWP has been purchasing water stored in a headwaters reservoir (Painted Rocks) for release into the Bitterroot River. With the help of a water commissioner to enforce legal water diversion, this tributary storage has greatly improved instream flows and has benefited recreation and the fishery.

Reservoirs have also served as staging or holding areas for migratory waterfowl. For example, Lima Reservoir in southwestern Montana supports one of the largest populations of molting Canada geese in Montana, as well as several breeding pairs of trumpeter swans. The presence of the molting geese below the reservoir's high cliffs has attracted two breeding pairs of peregrine falcons, an endangered species, to the area.

To a lesser extent, reservoirs have served as nesting areas for waterfowl, but fluctuating water levels common at most reservoirs have limited this activity. Waterfowl and wildlife also take advantage of the wetlands that are created around leaking canals and reservoirs.

Water storage has generally stabilized and expanded the irrigated agricultural economy in those locations where it was applied. Storage benefits irrigation to a varying extent in Montana. In some locations irrigation would not be feasible without storage, and in other places irrigation succeeds without storage. More often, storage has helped create significant supplemental irrigation. DNRC estimates that 1.7 million acre-feet of the 15 million acre-feet of water diverted for irrigation is supplied by storage (Appendices A and B present an inventory of existing water storage projects and water use in Montana). The number of acres affected is greater than these figures imply because much of the storage is used as supplemental irrigation. It is interesting to note that while irrigated acres account for only five percent of total cropland acreage, irrigated crop receipts account for 25 percent of total agricultural crop receipts.

Flood control is a beneficial effect that often is taken for granted. Because dams are such an effective control, we easily forget that society was once subjected to fairly frequent floods. These floods caused extensive property damage and occasionally resulted in loss of life. The Corps of Engineers estimates that in 1980, Clark Canyon Dam prevented $3,822,000 in flood damage, and Canyon Ferry Dam prevented $36,300,000 in flood damage.

Montana generated approximately 22,500 gigawatt-hours of electric power in 1986. Of this total, approximately 48 percent (approximately 11,000 gigawatt-hours) was generated by the state's hydroelectric plants. The Clark Fork Basin hydropower plants generate about 60 percent of the total hydropower generation, with the Missouri River Basin supplying the remaining portion. In the same year, approximately 55 percent (12,500 gigawatt-hours) of the total electricity generated was consumed in Montana. This consumption was serviced by all types of generating facilities. Electric hydropower plants generated nearly 100 percent of Montana's electric energy until the late 1960s and continued to generate the lion's share through the early 1970s. In the middle 1980s, thermoelectric power plants gained equal footing with hydroelectric power plants in terms of total generation.

The inexpensive, clean, and renewable nature of hydroelectric power makes it a desirable form of energy. Hydroelectric power is one of the primary reasons Montana and the Pacific Northwest in general enjoy inexpensive electric power relative to other regions of the country.

The development of small water storage projects has been important to Montana's cattle industry. Without these small stockwater ponds, much of Montana's rangeland could not support livestock. DNRC estimates There are approximately 8,000 small stockwater reservoirs in the state. BLM alone owns roughly 6,700 of these. Small stockwater reservoirs account for nearly 70 percent of the total number of reservoirs in Montana, but they provide less than one percent of the state's total storage capacity.

Storage projects also supply water for domestic and municipal consumption and industrial use, but these uses are relatively limited in Montana. There are about 52 municipal reservoirs in the state and a very small number of industrial water storage sites.

ADVERSE EFFECTS

In Montana, one of the most problematic adverse impacts of water storage is the inundation of big game winter range, excellent riparian habitat, good stream fisheries, river recreation areas, and prime agricultural land, homes, and towns. The resulting land-use conflicts have often been serious. For example, the inundation of Fort Peck resulted in the loss of thousands of acres of good bottom land and big game winter range. In other examples, such as Canyon Ferry, fisheries were lost. Excellent non-game species habitat has also been eliminated.

One of the most striking examples of the adverse effect of water storage development is the blockage of spawning runs of migratory fish in the Columbia River Basin. Hydroelectric development in the Columbia, Snake, Kootenai and Clark Fork basins nearly destroyed a valuable and unique fishery resource in Washington, Oregon, and Idaho, and severely altered resident fisheries in Montana. Today, millions of dollars are being spent to mitigate this damage by retrofitting existing dams to improve salmon migration and water temperature regimes and enhance spawning tributaries. Although mitigation efforts have greatly improved the situation, they cannot recreate the uniqueness of the original fishery and the associated recreational opportunities.

Many dams in the state in addition to those in the Clark Fork River Basin also disrupt spawning runs. Physically blocking spawning runs adversely impacts fish populations in streams or lakes where the migrating fish originate.

Storage reservoirs are designed to catch most of the high spring flows that typically shape a stream channel. Consequently, the channel becomes smaller, and there is a tendency for vegetation to encroach on the channel. This reduces the carrying capacity of the channel and promotes overland flooding when large runoff events do occur.

In addition, high spring flows reduce sediment accumulation that enhances aquatic habitat and fish populations. The reduced spring runoff (flushing) associated with reservoirs allows sediment to accumulate, which alters habitat for food organisms, degrades spawning habitat, and accordingly reduces fish populations and associated recreational opportunities. Reduced spring flows also inhibit upstream passage of spawning fish. Nevada Creek and Newlan Creek downstream of their respective dams are examples of streams that have been adversely impacted by reduced flushing flows. It is important to note that reduced spring runoff can also enhance a downstream fishery, depending on the original sediment load of the stream and magnitude of the reduction in flushing flows.

When a reservoir is built on a stream, it often serves as a trap for sediment. The equilibrium between the sediment picked up and transported and that deposited is disrupted. Because flows released from the reservoir do not carry sediment, they are able to pick up more from the channel and streambanks below the reservoir. The streambed and streambanks begin to erode, the channel becomes deeper, and streambeds become composed of coarser materials

below the dam as the river picks up and transports the fine sediment. Aquatic plant and insect communities may change as a result.

In some cases, nitrogen supersaturation problems could result from releases of water, causing what is known as gas bubble disease in fish. Properly designed outlet works can reduce this problem but add to project costs. If water in the lower portions of a reservoir is depleted of its oxygen, releases of water from the bottom of the reservoir may cause injury to aquatic organisms below the dam. In some cases, it is possible to reoxygenate this water as it is released or to select a suitable level in the reservoir for withdrawing water for release; again, this adds to project costs.

The temperature regime of streams below reservoirs is often changed. Reservoirs can act as heat sinks. Warmer water may be released during the fall and winter, but during the early summer, cooler than normal water may be released. The composition of the aquatic insect community and fish population below a reservoir might change as a result of the temperature changes. These conditions can be controlled by multi-gated outlets such as those at Libby Dam. Each reservoir and operating plan must be evaluated individually to determine whether such changes in the aquatic insect communities are significant.

Reservoir operation often adversely affects recreation and the downstream fishery, sometimes out of necessity and other times because of a lack of knowledge or consideration of the impact to other stream uses. In some instances, dam operators have reduced streamflows to a very low level or dried up streams while filling the reservoir. This, of course, severely limits the fishery and recreation uses. For example, Deadman's Basin is an offstream reservoir that diverts water from the Musselshell River. Below the diversion, flows are often reduced to a trickle. The brown trout population above the diversion is approximately three times that below the diversion. Low flow problems can be alleviated by suitable releases from the dam where such releases are possible, given consideration of other uses.

In some cases, reservoir releases are dramatically changed over a short period of time, leaving little opportunity for aquatic organisms and fish to adjust. The result is reduced food organisms and fish populations. This problem can be avoided by providing steady, gradual releases that allow aquatic organisms and fish to drift to more suitable habitat downstream. Progress is being made with regard to reservoir operation as operators become more aware and sensitive to fishery impacts and as streamflow prediction methods and resources improve.

Often, the relocation of roads, railroads, and power lines has created its own set of environmental problems that may affect a fishery. Relocation of the railroad up the Fisher River due to the construction of Libby Dam resulted in physical damage to the Fisher River, which reduced fish habitat substantially.

SUMMARY OF EFFECTS

From the previous discussion, it is clear that water storage can be very beneficial and can have significant adverse side effects. Just as clear is the site-specific nature of the effects of a reservoir.

The interaction between a reservoir and the surrounding environment can be complex and is unique to each storage site. For example, in some instances, the decreased sediment load and reduced flushing flows associated with a reservoir enhance the downstream fishery; in other situations, it degrades the downstream fishery. This contradiction is a result of the unique physical and aquatic characteristics of the affected stream. The social interactions are just as complex. Each individual views the many effects of reservoirs differently; accordingly, opinions differ about the value of water storage. Nor should it be taken for granted that additional water storage will always provide additional benefits. For instance, the addition of a reservoir to an area that presently offers considerable flatwater recreation does not provide new flatwater recreational opportunities and, therefore, little recreation benefit should be attributed to it. Such an addition might merely redistribute the recreational demand, with the only real net gain being convenience or increased privacy. The same type of logic applies to flood control. On the other hand, the reservoir might serve some unique purpose that is very beneficial such as enhanced stream flows for fisheries.

It becomes evident that the net effect of existing water storage and additional water storage cannot be simply characterized. The site-specific and incremental nature of the effects of water storage suggest that the role of additional storage be evaluated on a case-by-case basis, subject to the relative merits of the project being considered. Thorough basin-wide planning should precede any development, and all alternatives to resolving water shortage problems should be considered. Also, given the expense and complexities associated with water storage, any planning efforts should proceed prudently and in a phased manner to avoid unnecessary expenses.

ECONOMICS

DEVELOPMENT COST

Long before a project is ready for construction, considerable effort, coordination, time, and money is expended. Project planning and engineering costs vary considerably from project to project, and therefore do not lend themselves to generalization. It is sufficient to say that these costs are considerable. In the past, the federal government absorbed the majority of these costs for public projects. However, today's project sponsor will likely be required to cover a sizable portion of the planning and engineering costs.

Clearly, the construction of a large dam and reservoir drastically alters the status quo of the particular basin affected. Farms, homes, and even towns may be inundated; people, roads, utilities, and railroads may have to be relocated; wildlife movement and habitat uses will be altered; the environment may be degraded; and downstream homes will be put at risk. These impacts and many more will have to be compensated for. Consequently, the cost of development not only includes the building of the dam, spillways, outlet works, and access roads, but also includes the cost of compensation for displaced landowners, relocation of infrastructure, environmental mitigation, and property rights. Also, downstream property and human hazards may require that the dam be constructed in accordance with dam safety guidelines. The relative significance of these costs on the overall cost of project development will vary from one project to the next, depending on the physical features of the basin (geology, topography, hydrology, etc.), the extent of existing infrastructure, the quality of the site's natural surroundings, and the downstream hazard created by the dam. For example, one of the storage sites investigated under DNRC's Big Hole water storage study was estimated to cost $16,337,000. Due to rough terrain, the relocation of the existing road alone was estimated to cost $5,300,000.

Because of the many factors involved and the variability of project costs, it is not possible to describe the cost of water storage development in general terms. Probably the best way to understand the cost of water storage development is to review the cost of past projects and the estimated costs of undeveloped sites. Tables 2 and 3 are provided for this purpose. Table 2 lists several undeveloped sites studied by the Bureau of Reclamation and DNRC. These costs include planning, engineering, project construction, and other costs associated with construction (such as land acquisition and permits). Operation and maintenance costs are also included in the table. The costs were updated to 1988 dollars, converted to annual costs based on a 100-year term and an 8-7/8 percent interest rate, and divided by the firm annual yield (firm annual yield is the storage volume available during the driest period of the year on the driest year). This cost per acre-foot is shown in the last column of Table 2 and is an indication of the average annual cost of the project distributed over a 100-year service life. The actual finance cost will likely be distributed over a shorter term, and the annual cost would be higher, but the benefits are received throughout the project's service life. There are an infinite number of different financial scenarios that would alter the financial cost per acre-foot.

TABLE 2

Water Storage Development Cost for Selected Undeveloped Sites

	Firm Annual Yield (af)	1988 Const. Cost x1000	Annual[a] Cost x1000	Annual O&M x1000	Annual[b] Cost/af Yield x1000)
BU REC					
Sunday Creek	215,600	523,649	46,484	692	219
Buffalo Creek	27,480	115,390	10,243	153	378
Starved-to-Death	48,720	80,094	7,110	106	148
Tongue River	17,500	178,159	15,803	236	92
Little Bighorn	26,000	84,016	7,458	111	291
Mill Iron	21,400	25,227	2,239	33	106
Dry Lake	17,200	23,246	2,064	31	123
Reichle Dam	140,000	58,649	5,206	78	38
Milligan Dam	16,840	31,587	2,804	42	169
Flat Willow	30,000	53,512	4,750	71	161
Low Carter	None	505,099	44,838	669	None
Moorhead Dam	108,000	180,906	16,059	240	151
DNRC					
Pattengail	10,140	19,450	1,711	21	170
Wise River	25,630	15,916	1,413	21	56
Johnson Creek	5,000	9,641	856	12	174
Fatman	17,156	19,931	1,770	26	105

[a] Based on 100-year planning term at a discount rate of 8-7/8 percent.

[b] This is the cost of the project per acre-foot firm annual yield. Firm annual yield is the volume of storage that is available in driest period of the year. This column is a measure of the cost of the project through a 100-year life. Actual finance cost may be considerably higher.

Table 3 updates the cost of existing water storage projects. It is important to recognize that these projects were constructed based on standards at the time of construction that were less stringent than today's standards. Also, the costs reported in Table 2 do not include any rehabilitation costs that may have been incurred since construction. Therefore, the cost per acre-foot in the last column of Table 3 is likely lower than what it would actually cost today to build these same projects. However, Table 3 should provide the reader with some sense of the cost of water storage development. The costs in Tables 2 and 3 were updated using the Bureau of Reclamation's construction cost index. The annual cost per acre-foot in Table 3 was developed in the same manner as Table 2, except the active storage was used instead of firm annual yield because yield data was not available.

A further illustration of development costs is provided through Appendix B. This appendix lists 174 undeveloped sites identified in the SCS Upper Missouri River Basin study. These projects range in size from 1,600 acre-feet to 78,300 acre-feet. The 1988 annual cost per acre-foot varies between $5 per acre-foot to $174 per acre-foot. The average cost per acre-foot is $43. These costs are based on total storage capacity.

Many changes have taken place, both politically and physically, that make dam construction more expensive. The Teton Dam failure and several smaller dam failures have made the public aware of the need for dam safety. Consequently, more stringent design criteria and standards have been adopted, making dam construction more expensive (increased spillway size, etc.).

Environmental awareness has also increased during the past two decades, resulting in laws such as the National Environmental Protection Act (NEPA) and the Montana Environmental Protection Act (MEPA), both of which require an Environmental Assessment (EA) or Environmental Impact Statement (EIS) for development projects with federal or state involvement. Environmental impacts identified through this process must be mitigated. The result is higher costs due to necessary environmental mitigation.

Also, many of our best instream sites have already been developed. As a result, the remaining sites often have some physical limitation that may require extensive engineering or unique construction techniques. Accordingly, this special treatment is reflected in increased costs.

Another factor that may impact future storage costs has to do with the fact that all of our river basins are highly appropriated. This means that water is only available for short periods in the spring (25 to 30 days). Because of this, the storage system may have to be able to divert and control large flows. Consequently, the size of supply canals, pumps, road culverts, etc., must be large and therefore more expensive.

It is also important to recognize the long-term financial commitment required for annual operation and maintenance of additional water storage. This is likely to present a considerable challenge, given current budget constraints and the difficulty encountered maintaining existing projects.

TABLE 3

Construction Cost of Existing Water Storage Projects

DAM	CONSTRUCTION DATE	STORAGE VOL. (ACRE-FEET) ($1,000)	ORIGINAL CONST. COST	ORIGINAL COST/AF ($1,000)	1988 CONST. COST ($1,000)	1988 COST/AF	ANNUAL COST/AF (8.88%-100YR)
Nevada Creek Dam	1938-40	12,640	420	33.00	4,507	356	31.58
Nilan Dam	1951	10,000	409	41.00	2,041	204	18.10
Petrolia Dam	1951	9,192	492	53.00	2,458	267	23.68
Middle Creek Dam (Hyalite)	1938-51	8,027	709	88.00	3,542	441	39.12
Cottonwood Dam	1953	2,200	88	40.35	396	180	15.97
Canyon Ferry	1945-54	1,952,059	20,474	10.00	91,365	46	4.08
Frenchman	1949-53	7,010	491	70.00	2,192	312	27.68
Tiber Dam	1952-56	967,319	45,116	47.00	197,828	204	18.10
Helena Valley Dam	1957-58	10,451	4,339	415.00	16,830	1,610	142.84
Cateract Dam	1958-59	1,395	196	141.00	775	556	49.33
Lower Willow Creek Dam	1962	6,250	650	104.00	3,563	410	36.37
Box Elder Dam	1963	6,378	397	62.00	1,543	241	21.38
Clark Canyon Dam	1961-64	178,062	11,286	63.00	43,116	242	21.46
Jawbone Creek Watershed Dam #1	1966	2,442	52	21.00	193	79	7.00
Jawbone Creek Watershed Dam #2	1966	196	36	183.00	132	676	59.97
Yellowtail Dam	1961-66	1,070,029	70,240	66.00	258,537	241	21.38
Shelby Watershed Dam	1967	2,470	487	197.00	1,732	701	62.19
Sturgis Dam	1970	156	16	104.00	50	320	28.39
Christensen Dam	1970	77	16	218.00	51	673	59.71
Cedar Creek Dam	1971	2,730	760	278.00	2,177	797	70.71
Beaver Creek Dam	1974	8,822	1,765	200.00	4,123	467	41.43
Hanson Creek Dam	1974	840	631	752.00	1,476	1,757	155.88
East Fork Dam	1974	7,200	1,501	208.00	3,506	487	43.20
Baker Lake Floodwater Dam	1975	3,250	375	116.00	725	223	19.78
Big Casino Creek Dam #2	1976	2,000	1,119	560.00	1,987	993	88.09
Pike Creek Dam	1977	770	1,116	1,450.00	1,879	2,441	216.56

ECONOMIC VALUE

Because a detailed discussion of water storage economics is beyond the scope of this report, this section of the report merely tries to illustrate the economic value of some of the beneficial uses associated with storage and generally discusses several economic issues.

Attempts have been made to quantify the value of water per acre-foot for various beneficial uses. The typical uses include agriculture, industry, municipal, and recreation. While these efforts have value, they are typically sensitive to assumptions made during the analysis and, therefore, should be applied with caution. In 1984, a report submitted by Montana State University, "Economics of Water Marketing Options for Montana," placed values on an acre-foot of water for municipal, industrial, irrigation, and recreation uses. The results of this analysis provide some insight into the value of water from a general perspective. However, it is important to recognize that the value of water is site-specific and, when applied to a specific project, should be evaluated on its own merits.

Irrigation water values taken from the MSU report are listed in Table 4. These values vary considerably due to the value of the crops grown, local farming practices, etc. However, the values do establish an expected range of values.

The value of irrigation water in Montana as reported in this table varies from between $9.29/af to $59.50/af. The higher value corresponds to the relatively fertile soil and higher crop values of the Yellowstone River Basin. Also, the higher number includes returns to management, operator labor, and fixed factors of production, which should be subtracted from the $59.50/af figure. Consequently, the actual value may be considerably lower. This would be consistent with the lower value of $25/af, established by Tubbs ("Cooney Dam Rehabilitaion: An Ex-Post Analysis") for irrigation water in the Cooney Reservoir area.

Another way to view the value of irrigation water is to look at what is actually paid for the water. The annual assessments for state-owned projects administered by the DNRC range from between $.50/af to $20/af, with an average of $2.98/af. A survey of several irrigation districts suggests a range of $2/af to $10/af. Some of the values discussed in this section assume full-service irrigation. However, one of the expressed needs for water storage is to address irrigation water shortages. Reservoirs developed to address this need will provide supplemental irrigation benefits and therefore the value of water is less than that presented here.

TABLE 4

IRRIGATION WATER VALUES (Selected Studies)

Study	Study Area	Value[a] ($/af)
Gardner & Fullerton	Sevier Basin (Utah)	24.44
Anderson	South Platte (Colo.)	8.97-12.44
Sorenson & Clark	East Central Wyoming	4.97-13.05
Lindeborg	Snake River (Idaho)	43.58
Shumway	Salinas Valley (Calif.)	29.45-41.64
Grubb	Texas High Plains	60.29
Beattie	Texas High Plains	51.28
Young	Lower Colorado	42.42
	Texas High Plains	42.42
	Central Arizona	26.79
Hartman & Seastone	Imperial Valley (Calif.)	14.00
Frank & Beattie	Upper Missouri Basin (Mont.)	9.29[b]
	Northwestern Ogallala	21.39
Weatherford	Sevier Basin (Utah)	25.38-40.60[c]
	South Platte (Colo.)	15.23-81.20[c]
Peel	Yellowstone River (Mont.)	59.50[d]

[a] All values are in 1980 dollars.

[b] Region includes both Upper Missouri and Yellowstone River basins.

[c] Derived by discounting the value of permanent transfers of water rights reported in Weatherford (assuming a five percent real discount rate).

[d] Includes returns to management, operator labor, and fixed factors of production. Thus, $59.50 overstates the value of the water per se--perhaps considerably.

Source: "Economics of Water Marketing Options For Montana" MSU 1984.

If these values are compared to the costs discussed previously (see Tables 2 and 3), it becomes apparent that the development of single-purpose irrigation projects is a considerable challenge and, in most instances, will require the incorporation of other beneficial uses to justify the cost of development. The limitation, of course, is that the need for other purposes such as recreation flood control, industrial, instream flows, and hydropower must exist and be of sufficient value to justify project costs. Also, the reservoir must be operated to provide all of these beneficial uses, some of which may conflict.

The value of municipal water as reported in the MSU study is $261/af for the plains and mountain regions of the United States. A better indication of the value of municipal water is the recent contract between DNRC and the City of Bozeman for Middle Creek Reservoir water. The contract will call for the delivery of 5,000 acre-feet per year at approximately $40/af. Another example is the City of Helena, which spent nearly $1,000,000 at a cost of $103/af to rehabilitate Chessman Reservoir.

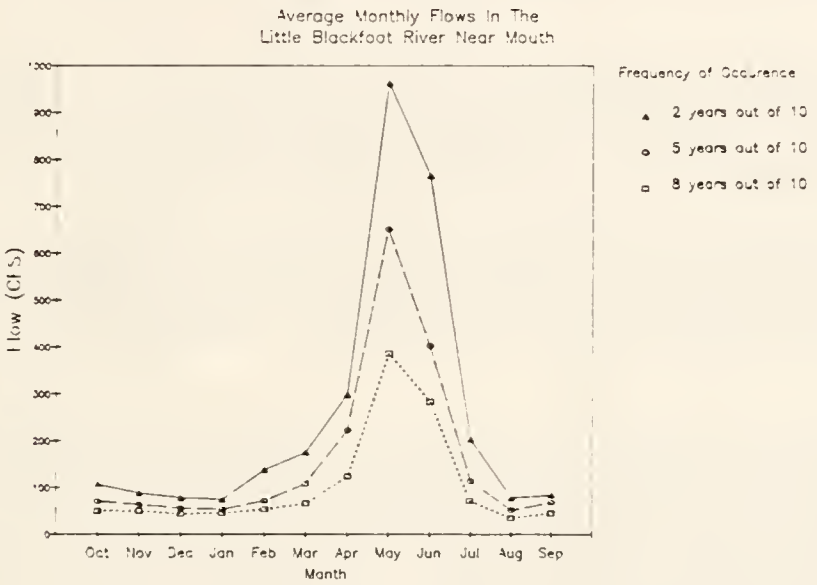
The value of industrial uses varies considerably. The MSU water marketing report suggests that the values range from $.03/af for wastewater dilution to $352/af for cooling. The opportunities to combine industrial uses with other uses for multipurpose development is restricted by the relatively limited industrial activity in the state. Occasional opportunities may exist.

Economic analysis provides a framework under which decisions regarding water resource development may be made and helps to optimize the type of development ultimately pursued. However, it is important to recognize the limitations of economic analysis. Economic studies attempt to evaluate all consequences in monetary units, but many values defy such quantification. Unique or extreme items or events may not lend themselves to monetary quantification. Examples include rare and endangered species, unusual beauty, unique landscapes, direct human health effects, and loss of life. Extra economic achievements associated with a water storage project such as increased income stability and improved quality of life are also not served well by economic analysis. All of these intangible values must be considered when making decisions regarding water resource development. Other limitations include the sensitivity of the results of economic analysis to assumptions and how the data is applied. This issue has prompted considerable debate in the federal water development arena. Over the years, there have been several attempts to coordinate and standardize the way federal agencies apply economic analysis. Consistency of federal economic evaluations has improved over the last four decades, but controversy remains.

While many may argue the merits of the federal approach to economic analysis, each federal water development agency does have a framework under which it makes water resource development decisions. This is not the case with the state of Montana. If the state does pursue water development projects, the development of such a framework may be necessary to control how water resource development values and costs are evaluated and applied to a development decision.

PHYSICAL WATER AVAILABILITY

Changes in the timing and amount of precipitation and snowpack from year to year are reflected in streamflows. Yearly and seasonal variations make it difficult to predict the amount of water available for development. Because huge fluctuations in streamflow are common, a statistical analysis must be applied to streamflow measurements to determine the volume of water available at a given time of the year at a specified level of reliability, e.g., eight years out of 10. The family of hydrographs presented in the figure below demonstrates the different volumes of water available at various levels of reliability.



Many of Montana's river basins are developed to the extent that demand meets or exceeds the reliable water supply. Because junior water right holders may have only the unreliable water supply available to them, they may suffer frequent water shortages. Water storage helps alleviate this problem by capturing the reliable spring runoff and making water available for use when it is needed.

It often appears that plenty of water is available for additional water storage. We all remember times when huge volumes of water flowed in our favorite creeks or rivers. However, if we kept track year in and year out over a long period of time, we might be surprised at the lack of consistency of these flows. Consequently, the ability of a reservoir to meet a particular water demand is dependent on the amount of water available in the basin on a reliable basis (eight out of 10 years for example). It has generally been impractical to develop storage projects based on the high flows that occur every few years (carry over storage). The water physically available for storage on a reliable basis must be evaluated for each water storage project

to establish project feasibility. As a result, water storage development may or may not be a technically or economically viable solution to a particular water shortage problem.

LEGAL WATER AVAILABILITY

Water use in Montana is generally guided by the legal principle known as the prior appropriation doctrine: "first in time is first in right." A user's right to a specific quantity of water depends on when the use began. The first person to use water from a source established the first right, the second person was free to divert flows from what was left, and so on. During a dry year, the person with the earliest date of use would have first chance at the available water to the limit of his established right. The holder of the second earliest priority date would have the next chance, and so on.

After passage of the Water Use Act in 1973, a permit must be issued by DNRC in order for water users to obtain a water right. A general adjudication is being conducted statewide by the courts to determine the validity of claims for pre-1973 water rights. The nature and extent of these claimed rights will not be determined until a final court decree is entered.

Many of Montana's river basins are highly appropriated, and the extent of legal constraints to the issuance of new water use permits is uncertain. To date, DNRC continues to issue new permits on most basins. However, changes could occur that would either constrain or enhance water storage development.

There are several reasons for the uncertainty over whether existing water rights would or would not constrain water availability. One reason is that the water court has not yet issued a final decree concerning water right claims in many of Montana's river basins, and the state is still in the adjudicating process. At present, claims in each basin as filed must be considered as valid, but the amount of water claimed may be changed during the final adjudication. If the amount of water decreed in the adjudication process is less than the amount claimed, there may be more unappropriated water available for future use than currently projected.

Another cause for uncertainty stems from the water right holders themselves. If the proposed new uses would adversely affect existing water rights, senior holders may choose to object to the application, but no one can be required to object. For example, Noxon Rapids Dam owned by Washington Water Power has the capacity to use 50,000 cfs. A recent water availability study (Holnbeck, 1988) suggests that there are only 22 days in which flows exceed WWP's water right claim (between May 25 and June 17 on the average). This situation might limit water availability for upstream development. Presently, all new water right permittees upstream of the dam are given notice of the hydropower claim at Noxon Rapids.

DNRC initiated discussions with WWP to determine the effect of issuing new consumptive use permits on WWP's hydropower uses and to establish the likelihood of WWP objecting to new permits. To date, WWP has not objected to the issuance of new permits in the basin.

In other cases, the downstream large hydropower water right holders have objected to upstream development or issuance of new water use permits. Presently, Montana Power Company (MPC) objects to each new water use permit issued on the Missouri River Basin above Cochrane Dam. The Bureau of Reclamation also objects to water use permits above Canyon Ferry Dam. Both MPC and the bureau argue that little unappropriated water exists above Canyon Ferry, and issuance of new permits infringes on their existing downstream rights.

It is also possible for water rights to be sold for other upstream uses, but only if the purchaser can demonstrate that the new use would not adversely affect other water right holders. For example, if a downstream hydropower producer were willing to sell a portion of its water rights and FERC approves the decision, it is possible that the rights could be purchased for new consumptive development in the upper basin.

An additional cause of uncertainty is the presence of unquantified federal reserved water rights. For example, claims have been made in the Clark Fork Basin by the U.S. Department of Agriculture for water rights for the national forests. Also, on behalf of the Confederated Salish and Kootenai tribes of the Flathead Reservation, the Bureau of Indian Affairs has filed a claim in the Clark Fork Basin for instream flows to protect aboriginal rights recognized by treaty. The nature and extent of water rights for these purposes will be determined within the state adjudication, either through negotiations with the Montana Reserved Water Rights Compact Commission or through the water court.

While no hydropower facilities or other large users exist on the main stem of the Yellowstone River that would tend to preclude development, future development is largely established by the reservation process. Reservation priority in the upper Yellowstone is municipal, instream flow, irrigation, and multipurpose. Reserved instream flow rights on the upper Yellowstone may restrict new development for projects other than municipal. Reservation priority in the lower Yellowstone is municipal, irrigation, instream, and multipurpose. Multipurpose storage reservations are the only storage reservations in the lower Yellowstone.

STATE ENVIRONMENTAL LAWS PERTAINING TO DAM CONSTRUCTION

Several environmental permits and approvals would be necessary prior to construction of new storage projects. The most notable is compliance with Montana's Environmental Policy Act (MEPA). According to the Environmental Quality Council (1988):

> Before any major action significantly affecting the quality of the environment is taken, a state agency must prepare an environmental impact statement (EIS) discussing the environmental impacts of the proposed action. The responsible state official must consult with and obtain the comments of any state agency which has jurisdiction by law or special expertise with respect to any environmental impact involved. Copies of the EIS and the comments and views of the appropriate state, federal and local agencies which are authorized to develop and enforce environmental standards must be made available to the Governor, the Environmental Quality council and the public and must accompany the proposal through the existing agency review processes. Alternatives to the proposal, irretrievable commitments of resources, and the relationship between short-term uses of the environment and long-term productivity must be discussed. The EIS requirement applies to issuance of state permits, licenses and approvals for private actions which will have significant environmental impacts.

At least two types of permits could be required by the Department of Health and Environmental Sciences (DHES). The first would be a short-term authorization to violate water quality standards pertaining to turbidity. This authorization would be required for construction activities that take place directly in a stream. The second would be for a discharge permit (discharges from a pipe) and would be required for activities such as pumping water from a foundation excavation. The newly constructed dams also would be required to meet the water quality standards during operations. The water quality standards specify that state waters must be free of discharges that create toxic concentrations harmful to human, animal, plant, and aquatic life or create conditions capable of producing undesirable aquatic life. The standards set limits for the allowable changes in stream temperature, increases in dissolved nitrogen, and decreases in dissolved oxygen among others. Last, if federal authorizations for work in a stream are required, such as a 404 Permit from the Army Corps of Engineers, approval from DHES also is required.

A lease or easement would be required from the Department of State Lands (DSL) if the storage project is located on state lands or a navigable stream. A mineral lease may be required by DSL if substantial amounts of fill material for dam construction are removed from state-owned lands. Requirements of the Open-Cut Mining Act may apply to removal of large amounts of fill material located on state or private lands. The Open-Cut Mining Act requires a reclamation plan for disturbed areas.

The State Historic Preservation Office becomes involved when state actions or state-licensed, -assisted, or -permitted actions have the potential to substantially alter heritage properties or paleontological remains on state-owned lands, as in excavation of heritage properties on state-owned lands.

> In consultation with the State Historic Preservation Office, the land management agency is required to determine whether a proposed action, initiated by the agency or by an applicant's request for a license or permit, may impact sites, structures or objects on state-owned lands that qualify or would qualify as heritage properties. If the action will affect such properties, the agency must seek ways to avoid or mitigate substantial alterations of the property whenever feasible. These procedures may require completion of a systematic cultural resources inventory, recordation of a property likely to be harmed, consideration of alternative projects, special protective stipulations, project modifications or denial of the project. Agencies may require applicants for permits or licenses to complete portions of this analysis. The land management agency is responsible for insuring that proper procedures are followed. After consultation with the Preservation Office, the agency is responsible for determining how to proceed with the proposed action (EQC 1988).

Last, EQC (1988) describes the types of permits required relating to streambank protection.

Any physical alteration of a natural flowing stream, its beds, or immediate banks requires approval from the Department of Fish, Wildlife and Parks or County Soil and Water Conservation District supervisors. In addition, a permit is required from the Army Corps of Engineers for any dredge and fill activity or other work affecting "waters of the United States." This includes dredge or fill activity in wetlands. The regulatory purposes are intended to preserve streams in their natural state and keep soil erosion and sedimentation to a minimum. Agricultural, commercial, fish, wildlife, and recreational recognition is considered in permitting requirements relating to streambank protection. There are appeal procedures for applicants or administering agencies if disputes arise over controversial projects.

The boards of supervisors or county commissioners are required to consult with DFWP prior to approval of instream construction activities. DFWP or an applicant may appeal the decision to an arbitration panel appointed by the senior district court judge.

DAM SAFETY

Dams are an integral part of society's infrastructure, but they present some risk to life and property. During the past decade, several major dam failures have increased public awareness of the potential hazards created by dams. As a result, several states have passed dam safety laws, and all federal agencies involved in dam construction and operation have put in place dam safety regulations. Montana followed suit in 1985 with the passage of the Montana Dam Safety Act.

Montana's Dam Safety Act

The Montana Dam Safety Act and regulations require that a hazard classification be performed prior to the construction of any dam with a capacity of 50 acre-feet or more. If it is found that upon failure of the dam a life could be lost, the dam is given a high-hazard classification, and a construction permit from DNRC is required. If the dam is not given a high-hazard classification, it does not have to comply with the Dam Safety Act. Federal dams are exempt from Montana law.

Construction plans, specifications, and a design report prepared by the owner's engineer are reviewed by the DNRC. If the plans and specifications meet the minimum standards for construction set out in state regulations, a construction permit is granted.

If construction is completed properly and an operation plan is satisfactory, then an operation permit is issued for a term of up to five years. The operation plan includes a reservoir operation procedure, a maintenance procedure, and emergency and warning plans. Preparation and adherence to the plans will increase the likelihood of safe operation and maintenance of high-hazard dams.

A periodic inspection of the high-hazard dam is necessary to renew the operation permit. The inspection must be conducted by a licensed professional engineer and is the responsibility of the dam owner.

Existing high-hazard dams that were inspected by the Corps of Engineers must receive a construction permit for alterations after July 1, 1990, and an operating permit by July 1, 1995. Non-Corps-inspected dams currently must receive construction permits for any alterations, and an operation permit is required by October 1, 1990.

Prior to passage of the Dam Safety Act, the owner of a high-hazard dam or reservoir was strictly liable for damages or loss of life caused by the failure of his dam. Under the law, the owner is not liable for damages, in the absence of negligence or damages from flows above the 100-year floodplain.

The Impact

In 1980 the Corps of Engineers inventoried 3,500 dams in Montana and identified 118 high-hazard dams or reservoirs. Accordingly, only those

structures must comply with the Montana Dam Safety Act. Other dams may come under compliance if new information supports a high-hazard determination.

Many of Montana's dams were built before much data existed on historical streamflows and weather patterns. This, coupled with the lack of spillway criteria, resulted in the under-design of many spillways. As a result, many of the state's dams are unable to pass significant flood events without overtopping. The International Commission on Large Dams reports that 35 percent of the failures of earth dams are due to overtopping. Consequently, many of the 118 high-hazard dams in Montana must have their spillways enlarged to prevent potential failures.

Many of Montana's dams were built before the advent of air-entrained concrete and its associated strength and durability. There was also a tendency to work with wet concrete in the first part of the century and, as a result, the structural strength of the concrete suffered. These factors, combined with the fact that many of the structures are over 50 years old, result in structural problems with some dam outlet works and appurtenances.

Geologic or foundation conditions are very important to the stability of a dam. The International Commission on Large Dams states that 21 percent of dam failures are a result of foundation failures. Past geotechnical techniques were not as sophisticated as today's. Therefore, in some cases, dams were constructed on poor foundations. This has occurred in some situations in Montana. Where it has occurred, the costs to rehabilitate may be extremely high.

Another significant mode of failure is piping and seepage. Because seepage and drainage control techniques were not as well developed in the past, some of the state's embankments suffer from seepage problems. Repair of these conditions is relatively inexpensive compared to spillway, outlet, and foundation concerns.

Most of the 118 high-hazard dams that were declared unsafe by the Corps of Engineers suffer from one or all of these problems. Each has a different combination of problems and are subject to varying degrees of severity. The cost to rehabilitate these projects vary considerably, anywhere from a few hundred thousand dollars to millions of dollars. Consider a few examples of the actual and estimated costs presented in Table 5.

TABLE 5

Cost of Dam Rehabilitation

Dam	Dam Height (Feet)	Reservoir Storage (Acre-feet)	Feasibility Studies	Construction & Engineering
Cottonwood	37	1,400	$ 20,000[a]	$ 222,000[b]
Yellow Water	37	4,242	$ 10,000[a]	$ 221,000[b]
Middle Creek	110	8,027	$250,000[a]	$5,000,000[a]
Petrolia	55	9,102	$ 23,000[b]	$3,000,000[a]
Lima	54	75,180	$116,000[b]	$2,500,000[a]
Beaver Creek	108	8,700	$ 70,000[b]	$ 189,000[a]

[a] Estimated cost

[b] Actual cost

APPENDIX A

EXISTING MONTANA WATER STORAGE

Today, Montana has an estimated 11,000 reservoirs ranging in size from small stockwater ponds to large multipurpose reservoirs impounding millions of acre-feet (see Table 6). Together, these reservoirs have the capacity to store approximately 33 million acre-feet of water. Roughly half of this storage capacity is available through Fort Peck Reservoir alone. In fact, Montana's eight largest reservoirs account for 91 percent of the state's total storage capacity. The eight largest reservoirs are Fort Peck, Canyon Ferry, Hungry Horse, Big Horn Lake (Yellowtail Dam), Lake Elwell (Tiber Dam), Flathead (Kerr Dam), Lake Koocanusa (Libby Dam), and Noxon Rapids.

TABLE 6

Montana Water Storage

Class	Number	Storage Capacity (af)	Percent	Primary Purpose
Large Reservoirs	8	30,222,300	91	Hydropower Recreation
Medium Reservoirs	3,483	2,785,750	8	Stockwater & Irrigation
Small Reservoirs	8,000	100,000	<1	Stockwater
TOTAL	11,491	33,065,050	100%	

While the eight largest reservoirs provide the majority of the storage, the small reservoirs are by far the greatest in number. There are an estimated 8,000 small reservoirs (see Table 6). The definition of the small reservoirs listed in Table 6 is those reservoirs that did not meet DNRC's 1981 dam safety inventory size criteria. This inventory lists dams that (a) have a dam height equal to or greater than 25 feet and a storage capacity of 15 acre-feet or more; or (b) have a dam height equal to or greater than six feet and a storage capacity of 50 acre-feet or more. The vast majority of these small reservoirs are stockwater ponds. Even though there are a large number of small reservoirs, they account for less than one percent (100,000 acre-feet) of the state's total water storage capacity. Many of these small reservoirs (approximately 6,500) are owned by the Bureau of Land Management.

Medium-sized reservoirs are defined as those projects meeting the previously described dam safety criteria exclusive of the state's largest reservoirs. There are approximately 3,500 medium-sized reservoirs, which

together provide an estimated 2.8 million acre-feet of storage capacity (see Table 6). Of the 3,500 medium-sized reservoirs, approximately 969 are primarily irrigation projects with a total water storage capacity of 1.8 million acre-feet. Many of the reservoirs provide secondary recreational benefits. Table 7 presents the distribution of ownership by water storage capacity of the medium-sized irrigation reservoirs. The other private projects category in Table 7 includes hundreds of smaller, privately owned irrigation reservoirs. Essentially, Table 7 attributes 41 percent of the irrigation storage provided by medium-sized reservoirs to the Bureau of Reclamation, 36 percent to various private projects, and 23 percent to the Department of Natural Resources. This does not include the irrigation benefit of the eight largest reservoirs. However, only Canyon Ferry provides much direct irrigation benefit.

TABLE 7

Ownership of Medium-sized Irrigation Reservoirs

OWNER	NUMBER	STORAGE CAPACITY (af)	PERCENT
Bureau of Reclamation	10	711,973	41
DNRC	28	394,229	23
Water Users Irrigation Co.	1	84,050	5
Pondera Canal Co.	1	105,000	6
Teton Cooperative Canal Co.	2	92,500	5
Other Private Projects	927	354,069	20
TOTALS	969	1,741,821	100%

The federal government owns about 483 of the total medium- and large-sized reservoirs listed in Table 6 (3,491 reservoirs) and accounts for 89 percent (29 million af) of Montana's total water storage capacity (33 million af). Federal ownership is further described in Table 8. As expected, the Bureau of Reclamation and the Corps of Engineers provide nearly all of the federal water storage capacity and, therefore, the majority (88 percent) of the state's total storage capacity. It is interesting to note that the Corps owns only two projects (Libby and Fort Peck Dams) but provides 64 percent of Montana's water storage capacity. The remainder of the federal projects consists of several smaller projects owned by various federal agencies.

TABLE 8

Federally Owned Storage Projects

AGENCY	NUMBER	STORAGE CAPACITY (af)	PERCENT	AVERAGE CAPACITY (af)
Bureau of Rec	14	7,967,273	24.1	398,364
Corps of Engineers	2	21,209,000	64.1	---
Bureau of Land Mgmt	391	61,609	<1	158
Fish & Wildlife Serv	21	105,013	<1	5,001
Forest Service	21	61,335	<1	2,921
Bur of Indian Aff	28	108,431	<1	3,873
TOTALS	466	29,512,661	89.3	

The State of Montana owns about 196 reservoirs. The total storage capacity of the state-owned projects is about 400,000 acre-feet. State agency involvement is shown in Table 9. The "Others" category in Table 9 is mostly State Water Conservation Board projects that have since been released and certain reservoirs on state lands. The Department of Fish, Wildlife, and Parks owns 16 reservoirs, but only four showed up in DNRC's dam safety inventory because of size criteria. DNRC administers the larger state-owned projects and provides most of the state-owned irrigation water storage capacity.

TABLE 9

State-owned Storage Projects

AGENCY	NUMBER	STORAGE CAPACITY(af)	PERCENT	AVERAGE CAP.(af)
DNRC	28	394,229	1.2	14,080
DFWP	4	1,951	<1	480
Others	164	12,553	<1	77
TOTALS	196	408,733	1.2	

The total number of medium- and large-sized reservoirs identified in Table 6 remaining after the state and federally owned reservoirs are subtracted is 2,812. Of this total, 52 are owned by municipalities, seven by counties, 120 by Indian reservations, and 2,633 by private organizations such as utilities, canal companies, and individuals. Montana Power Company, at approximately 1.8 million acre-feet (1.5 percent of Montana's storage), owns the majority of private water storage. Table 10 presents Montana water

storage not including federal and state-owned projects (9.5 percent of Montana's total storage).

TABLE 10

Water Storage Other than Federal and State-owned Projects

OWNER	NUMBER	STORAGE CAPACITY(af)	PERCENT	AVERAGE CAP. (af)
Montana Power Co	27	1,872,835	5.7	69,364
Washington Power Co	1	495,000	1.5	---
Others	2,793	775,821	2.3	278
TOTALS	2,821	3,143,656	9.5	

Water Use

The National Water Use Data System (NWUDS) is a cooperative program of the United States Geological Survey (USGS) and the Montana Department of Natural Resources and Conservation (DNRC). Information on water use is collected through the data system. Water use for 1980 is reported in Table 11. Seven kinds of water use were estimated: municipal, hydroelectric power generation, thermoelectric power generation, self-supplied industrial, rural domestic, livestock, and irrigation. Evaporative loss of water from reservoirs was also estimated.

In addition to the offstream uses shown in Table 6, about 73,984,000 acre-feet of water was used to generate hydroelectricity. After powering the turbines, this water was returned to the stream for reuse. Reservoir evaporation accounted for a loss of 3,925,000 acre-feet of water in Montana river basins in 1980.

TABLE 11

Water Withdrawn and Consumed in Montana in 1980

Use	Water Withdrawn (Acre-feet)	Water Consumed (Acre-feet)
Irrigation	15,044,000	3,251,000
Municipal	157,000	58,000
Rural domestic	16,000	16,000
Self-supplied industry	62,000	9,000
Livestock	28,000	28,000
Thermoelectric power generation	107,000	9,000
TOTAL	15,414,000	3,371,000

In an average year, almost 44 million acre-feet of water flows out of Montana. Of this amount, 65 percent originates in the state. The Clark Fork river basin occupies less than 17 percent of Montana's surface area, but basin runoff exceeds 50 percent of the state's total stream flow. This of course means that the Yellowstone, Missouri, and Hudson Bay river basins occupy 83 percent of the state's surface area and produce less than 50 percent of the state's total streamflow.

APPENDIX B

UNDEVELOPED SITES

Over the years, hundreds of potential water storage sites have been identified and investigated at varying levels of detail. The vast majority of these sites have only been investigated on a reconnaissance level. Such an effort uses limited geologic, engineering, economic, social and environmental information and, therefore, care must be exercised in using the results of the study. A short bibliography of various studies identifying a site or sites is presented below.

1. Summary of Potential Projects in Montana, Inventory Series No. 9. Montana Water Resources Board, June 1968.

2. Offstream Storage, Yellowstone River Montana, Appraisal Report, United States Bureau of Reclamation, February 1984.

3. Water Storage in the Big Hole: A Recommendation, Montana Department of Natural Resources and Conservation, January 1981

4. Report on Potentials of Eastern Montana Basins, United States Bureau of Reclamation, 1977

One of the more comprehensive listings is a tabulation compiled by the Montana Water Resources Board in 1969. This report lists potential water resource projects that have been investigated by state and federal agencies and local organizations. The level of detail of the investigations ranged from reconnaissance-level efforts to detailed project studies. Six hundred and sixty-three reservoir sites were identified in this tabulation.

Another fairly large, potential-sites compilation was prepared by the Soil Conservation Service and includes projects investigated as potential watershed projects (P.L. 566) or as part of the Upper Missouri River Cooperative River Basin Study. Several hundred sites were investigated and are listed at the end of this appendix. Also listed are a few specific undeveloped projects.

The Department of Natural Resources and Conservation does not endorse any of the specific projects listed in this report or any other report identified herein. This information is made available to facilitate informed discussion on the viability of storage development.

SOIL CONSERVATION SERVICE UNDEVELOPED SITES INVENTORY

WATERCOURSE	ESTIMATED COST 1978 DOLLARS	STORAGE (A.F.)	1988 ESTIMATED COST	1988 COST/A.F.
Big Beaver Creek	$2,112,700.00	7500	$3,190,177.00	425
Muddy Creek	$2,644,600.00	5900	$3,993,346.00	677
Nicholia & Meadow Creek	$4,544,800.00	14600	$6,862,648.00	470
Cabin Creek	$5,079,600.00	12900	$7,670,196.00	595
Big Sheep Creek	$3,636,700.00	19900	$5,491,417.00	276
	$1,619,900.00	19900	$2,446,049.00	123
	$2,177,200.00	19900	$3,287,572.00	165
Sage Creek	$1,235,900.00	5200	$1,866,209.00	359
Trail Creek	$3,880,300.00	6500	$5,859,253.00	901
	$3,198,300.00	6500	$4,829,433.00	743
Medicine Lodge Creek	$5,779,900.00	15700	$8,727,649.00	556
Selway Creek	$2,029,800.00	8500	$3,064,998.00	361
Bloody Dick Creek	$1,902,500.00	11700	$2,872,775.00	246
	$5,037,100.00	15700	$7,606,021.00	484
	$5,228,200.00	15700	$7,894,582.00	503
	$3,977,500.00	15700	$6,006,025.00	383
	$4,026,200.00	15700	$6,079,562.00	387
	$5,927,000.00	15700	$8,949,770.00	570
Horse Prairie Creek	$5,159,300.00	15700	$7,790,543.00	496
Grasshopper Creek	$2,689,200.00	6300	$4,060,692.00	645
Ermont Gulch	$8,203,600.00	14300	$12,387,436.00	866
	$7,863,700.00	14300	$11,874,187.00	830
Rattlesnake Creek	$6,502,600.00	14300	$9,818,926.00	687
	$4,011,000.00	14300	$6,056,610.00	424
Birch Creek	$4,527,800.00	7600	$6,836,978.00	900
	$2,750,700.00	11500	$4,153,557.00	361
Willow Creek	$3,833,100.00	11500	$5,787,981.00	503
	$3,844,600.00	11500	$5,805,346.00	505
Blacktail Deer Creek	$2,937,000.00	10150	$4,434,870.00	437
	$4,667,700.00	19650	$7,048,227.00	359
	$5,178,400.00	30300	$7,819,384.00	258
Steel Creek	$1,935,800.00	3600	$2,923,058.00	812
Warm Springs Creek	$1,537,400.00	5100	$2,321,474.00	455
	$1,336,000.00	6900	$2,017,360.00	292
	$4,786,200.00	13600	$7,227,162.00	531
	$3,890,800.00	13600	$5,875,108.00	432
	$4,081,900.00	13600	$6,163,669.00	453
Butler Creek	$1,200,900.00	2700	$1,813,359.00	672
Ruby Creek	$1,935,100.00	5400	$2,922,001.00	541
Moose Creek	$2,793,900.00	3100	$4,218,789.00	1361
Trail Creek	$3,638,900.00	15120	$5,494,739.00	363
	$4,239,800.00	22900	$6,402,098.00	280
Tie Creek	$3,070,900.00	11650	$4,637,059.00	398
Johnson Creek	$2,979,800.00	10350	$4,499,498.00	435
Mussigbrod Creek	$1,186,100.00	9150	$1,791,011.00	196
Plimpton Creek	$2,507,200.00	5500	$3,785,872.00	688
Thompson Creek	$439,200.00	5050	$663,192.00	131
Pintlar Creek	$307,400.00	4200	$464,174.00	111
Peoples Creek	$1,429,750.00	4350	$2,158,922.50	496
	$1,641,560.00	6050	$2,478,755.60	410
	$2,233,557.00	10000	$3,372,671.07	337

SOIL CONSERVATION SERVICE UNDEVELOPED SITES INVENTORY

WATERCOURSE	ESTIMATED COST 1978 DOLLARS	STORAGE (A.F.)	1988 ESTIMATED COST	1988 COST/A.F.
S. Fork Peoples Creek	$2,765,155.00	16600	$4,175,384.05	252
Battle Creek & Lodge Creek	$2,085,000.00	11850	$3,148,350.00	266
Cow Creek	$1,679,984.00	6900	$2,536,775.84	368
Clear Creek	$2,023,932.00	5900	$3,056,137.32	518
	$2,495,350.00	6750	$3,767,978.50	558
	$2,193,012.00	7750	$3,311,448.12	427
	$2,331,857.00	7750	$3,521,104.07	454
Bean Creek	$778,687.00	3300	$1,175,817.37	356
Snake Creek	$2,642,927.00	9100	$3,990,819.77	439
Canyon Ferry Reservoir	$1,700,000.00	3908	$2,567,000.00	657
(Eastside-Cottonwood Cr.)	$13,750,000.00	25500	$20,762,500.00	814
Canyon Ferry Reservoir	$4,770,000.00	13800	$7,202,700.00	522
(Eastside - Deep Creek)			$0.00	N/A
Sixmile Creek	$572,500.00	3300	$864,475.00	262
Canyon Ferry Reservoir	$8,480,000.00	13380	$12,804,800.00	957
(Eastside-Ray Creek)			$0.00	N/A
Crow Creek	$11,250,000.00	24500	$16,987,500.00	693
Shonkin Creek	$3,227,900.00	121000	$4,874,129.00	40
W. Fork Poplar River	$1,393,100.00	3570	$2,103,581.00	589
	$2,624,300.00	6850	$3,962,693.00	578
	$2,720,000.00	9950	$4,107,200.00	413
Poplar River	$4,468,300.00	10000	$6,747,133.00	675
E. Fork Poplar River	$4,196,900.00	7900	$6,337,319.00	802
Ross Creek	$1,048,200.00	3900	$1,582,782.00	406
	$1,470,653.00	7140	$2,220,686.03	311
	$2,399,250.00	9400	$3,622,867.50	385
Judith River	$2,761,500.00	10270	$4,169,865.00	406
	$4,507,500.00	19300	$6,806,325.00	353
Rock Creek	$4,933,500.00	10200	$7,449,585.00	730
Little Trout Creek	$1,456,500.00	3100	$2,199,315.00	709
	$1,961,000.00	5000	$2,961,110.00	592
Cottonwood Creek	$3,016,000.00	6750	$4,554,160.00	675
Beaver Creek	$5,338,500.00	6100	$8,061,135.00	1321
	$2,825,100.00	6100	$4,265,901.00	699
Boyd-Big Spring Creek	$2,835,000.00	2150	$4,280,850.00	1991
	$2,008,500.00	3200	$3,032,835.00	948
Warm Spring Creek	$2,953,750.00	8900	$4,460,162.50	501
	$1,937,800.00	8900	$2,926,078.00	329
Wolf Creek-Coyote Creek	$1,915,000.00	5050	$2,891,650.00	573
N. Fork Flat Willow	$5,808,500.00	16100	$8,770,835.00	545
S. Fork Flat Willow	$5,610,200.00	16100	$8,471,402.00	526
S. Fork McDonald Creek			$0.00	N/A
Tyler Creek	$6,480,000.00	13100	$9,784,800.00	747
Bear Creek	$8,777,200.00	14700	$13,253,572.00	902
Blacktail Creek	$9,948,000.00	22250	$15,021,480.00	675
N. Fork McDonald Creek	$2,531,100.00	3500	$3,821,961.00	1092
	$1,264,700.00	4950	$1,909,697.00	386
Menard-Dry Creek	$413,375.00	3900	$624,196.25	160
Big Dry Creek	$2,542,800.00	7050	$3,839,628.00	545
Little Dry Creek	$1,089,400.00	2800	$1,644,994.00	587
Milk River	$3,324,600.00	12800	$5,020,146.00	392

SOIL CONSERVATION SERVICE UNDEVELOPED SITES INVENTORY

WATERCOURSE	ESTIMATED COST 1978 DOLLARS	STORAGE (A.F.)	1988 ESTIMATED COST	1988 COST/A.F.
	$3,804,300.00	18750	$5,744,493.00	306
	$5,000,000.00	18750	$7,550,000.00	403
	$3,227,300.00	18750	$4,873,223.00	260
	$8,143,700.00	53000	$12,296,987.00	232
	$9,414,000.00	53000	$14,215,140.00	268
N. Fork Milk River	$2,793,250.00	9000	$4,217,807.50	469
St. Mary River	$8,894,000.00	78300	$13,429,940.00	172
	$4,557,000.00	69300	$6,881,070.00	99
	$2,264,200.00	69300	$3,418,942.00	49
Flatiron-Willow Creeks	$2,165,750.00	16900	$3,270,282.50	194
	$1,301,750.00	15000	$1,965,642.50	131
	$1,136,500.00	7000	$1,716,115.00	245
Big Rocky Coulee	$762,350.00	1600	$1,151,148.50	719
Little Rocky Coulee	$665,000.00	3300	$1,004,150.00	304
Cut Bank Creek	$3,525,500.00	29000	$5,323,505.00	184
	$5,152,500.00	29000	$7,780,275.00	268
	$3,124,750.00	29000	$4,718,372.50	163
	$5,587,125.00	29000	$8,436,558.75	291
Two Medicine River	$6,321,000.00	68000	$9,544,710.00	140
	$6,825,325.00	68000	$10,306,240.75	152
	$8,443,500.00	68000	$12,749,685.00	187
Little Boxelder Creek	$1,256,400.00	3150	$1,897,164.00	602
Big Pipstone Creek-Delmoe Lake	$216,250.00	3700	$326,537.50	88
	$3,763,000.00	4720	$5,682,130.00	1204
Whitetail Creek	$2,618,750.00	7300	$3,954,312.50	542
	$2,822,500.00	7300	$4,261,975.00	584
	$2,477,750.00	7300	$3,741,402.50	513
Lone Tree Creek	$1,290,500.00	1950	$1,948,655.00	999
Judith River	$6,698,600.00	29500	$10,114,886.00	343
	$4,469,300.00	29500	$6,748,643.00	229
Waite Creek	$1,292,000.00	1800	$1,950,920.00	1084
Courtney Creek	$1,629,000.00	5230	$2,459,790.00	470
Antelope Creek	$1,416,300.00	2550	$2,138,613.00	839
Dry Wolf Creek	$1,582,900.00	2100	$2,390,179.00	1138
Running Wolf Creek	$1,603,300.00	3030	$2,420,983.00	799
Skull Creek	$1,160,300.00	3030	$1,752,053.00	578
Flat Creek	$660,500.00	4500	$997,355.00	222
	$821,500.00	4500	$1,240,465.00	276
Dry Creek	$656,250.00	4675	$990,937.50	212
	$1,131,250.00	8150	$1,708,187.50	210
Smith Creek	$1,976,333.00	14600	$2,984,262.83	204
Elk Creek	$2,788,500.00	11600	$4,210,635.00	363
Little Prickly Pear Cr.	$5,607,500.00	11200	$8,467,325.00	756
Jack Creek	$1,712,500.00	4900	$2,585,875.00	528
Cedar Creek	$5,000,000.00	4900	$7,550,000.00	1541
N. Fork Musselshell-Spring Cr.	$2,275,000.00	7200	$3,435,250.00	477
Cottonwood Creek	$1,376,000.00	4000	$2,077,760.00	519
	$1,142,875.00	5400	$1,725,741.25	320
Sixteen Mile Creek	$908,250.00	3600	$1,371,457.50	381
S. Fork Smith River	$1,103,750.00	3380	$1,666,662.50	493
	$2,969,250.00	9650	$4,483,567.50	465

SOIL CONSERVATION SERVICE UNDEVELOPED SITES INVENTORY

WATERCOURSE	ESTIMATED COST 1978 DOLLARS	STORAGE (A.F.)	1988 ESTIMATED COST	1988 COST/A.F.
Smith River-			$0.00	N/A
Lake Sutherlin	$527,000.00	3800	$795,770.00	209
Musselshell River-Horse	$1,014,800.00	3000	$1,532,348.00	511
Thief Creek	$1,052,400.00	3000	$1,589,124.00	530
Willow Creek	$2,338,300.00	10600	$3,530,833.00	333
Beaver Creek-Flat Creek	$1,515,200.00	5800	$2,287,952.00	394
	$1,391,300.00	6070	$2,100,863.00	346
Birch Creek Flats	$1,028,880.00	6800	$1,553,608.80	228
	$3,137,400.00	28500	$4,737,474.00	166
Dupuyer Creek	$7,220,742.00	19500	$10,903,320.42	559
	$6,030,661.00	19500	$9,106,298.11	467
Lake Theboe	$846,988.00	4600	$1,278,951.88	278
S. Fork Willow Cr.	$1,808,245.00	7200	$2,730,449.95	379
N. Fork Willow Cr.	$1,274,890.00	3400	$1,925,083.90	566
	$706,203.00	3400	$1,066,366.53	314
Willow Creek	$5,056,765.00	15900	$7,635,715.15	480
	$4,643,312.00	15900	$7,011,401.12	441
Deep Creek	$5,722,685.00	18500	$8,641,254.35	467
	$3,004,150.00	21000	$4,536,266.50	216
Willow Creek	$565,438.00	2100	$853,811.38	407
Milk River	$4,486,000.00	31000	$6,773,860.00	219
Porcupine Creek	$3,221,200.00	10700	$4,864,012.00	455
	$2,547,900.00	10700	$3,847,329.00	360
Little Porcupine Creek	$1,388,300.00	2900	$2,096,333.00	723
	$1,581,600.00	3150	$2,388,216.00	758
Rock Creek-Willow Creek	$3,300,000.00	13000	$4,983,000.00	383
American Fork	$5,240,300.00	12950	$7,912,853.00	611
Lebo Creek	$2,179,300.00	14830	$3,290,743.00	222
Big Elk Creek	$1,858,900.00	4500	$2,806,939.00	624
Musselshell River			$0.00	N/A
Little Elk Creek	$1,289,000.00	3700	$1,946,390.00	526
Daisy Dean Creek	$1,821,500.00	4460	$2,750,465.00	617
Haymaker Creek			$0.00	N/A
	$3,286,800.00	8760	$4,963,068.00	567
	$3,979,900.00	9230	$6,009,649.00	N/A

REFERENCES

Energy Information Administration, Historical Plant Cost and Annual Production Expenses for Selected Electric Plants, 1986.

Foster, Charles H.W., and Peter P. Rodgers, Federal Water Policy: Toward an Agenda for Action, Energy and Environmental Policy Center, John F. Kennedy School of Government, Harvard University, Cambridge. August 1988.

Holnbeck, Steve, Investigation of Water Availability for Clark Fork Basin Above Noxon Rapids Dam, Montana Department of Natural Resources and Conservation. October 1988.

Kelly, R.J., State Water Conservation Board Summary of Activities, (Kelly Report), State Water Conservation Board, March 1961.

Montana Department of Natural Resources and Conservation, Montana Water Use In 1980, Water Resources Division, March 1986.

_____ State Water Conservation Projects, Water Resources Division, March 1977.

_____ Water Availability and Future Water Development in the Missouri River Basin of Montana, Draft, December 1984.

Steele, Lynda, Montana Historical Energy Statistics, Montana Department of Natural Resources and Conservation, February 1984.

Tubbs, John, Cooney Dam Rehabilitation: An Ex-Post Analysis, Montana Department of Natural Resources and Conservation, May 9, 1986.

_____ and Tom Ring, coordinators, Upper Clark Fork Basin Water Reservation Applications Draft Environmental Impact Statement, Montana Department of Natural Resources and Conservation, December 1988.

United States Army Corps of Engineers, Water Resources Development - Montana, U.S., January 1979.

United States Bureau of Reclamation, Bureau of Reclamation Project Data, May 1981.

_____ Pick-Sloan Missouri Basin Program, no date.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION
1520 EAST SIXTH AVENUE HELENA, MONTANA 59620-2301